BUILDING SIMULATION REPORT FOR GUILDFORD BOROUGH COUNCIL

A Mixed Use Scheme – Large Office Building

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Contents

1. INTRODUCTION

This building simulation report summarises the findings of eight simulations on two building energy models of a large office building. These models are based on an actual building that has been adapted for the purpose of this study.

The simulations study the performance of two different but common building services solutions for mechanically ventilated office premises, which we refer to throughout this report as System 1 and System 2. In both building models the building fabric, lighting and domestic hot water are the same. However, the heating, ventilation and air conditioning (HVAC) strategy varies in each building. Low and Zero Carbon (LZC) technologies are incorporated to augment or replace conventional non-LZC technologies.

The modelled simulations calculate a building's Built Emission Rate (BER) as a result of the energy it is predicted to consume. Templates around occupancy and occupational parameters, such as hours of operation and temperature set points, are provided in a National Calculation Method (NCM) which was developed by the Building Research Establishment (BRE) for government. To comply with Part L2A *Conservation of fuel and power in buildings other than dwellings* of Building Regulations (Part L2A), a Target Emission Rate (TER) is set and the BER must achieve or better (≤) this target. The TER is based on the performance of the Notional Building which is also defined in the NCM.

In addition to building regulations, the TER is used in planning policy as a benchmark for sustainable development by setting out the maximum level of predicted CO_2 emissions that a building or development is permitted to emit. As part of an extant planning policy Guildford Borough Council (GBC) requires the BER of a new building to be at least 10% lower than the TER, with any reduction achieved through the use of on-site LZC technologies.

GBC is currently in consultation to increase this target to either 15 or 20% and this document forms part of a series of reports to help determine if these targets are technically feasible, and if so, what the potential effect of revising this policy would be in terms of development costs to property developers.

1.1. The Simulations

Part L2A has five criterion and a requirement for any developer to analyse and take into account the technical, environmental and economic feasibility of using high-efficiency alternative systems in construction, if available[1]. For a building to pass the exacting requirements of Part L2A it must be designed and constructed to a standard that meets or betters the TER of a Notional Building (BER ≤ TER.). A building that is constructed to the limiting parameters of Part L2A will fail Criterion 1, which is the Criterion that requires the BER ≤ TER.

Each model simulated is identical in every respect other than its building services, which may or may not include renewable energy systems. To ensure that the model is capable of passing Part L2A the building fabric is based upon the requirements of a Notional Building, and these remain unchanged throughout the various iterations of the model(s). By ensuring that the building construction and fabric remains as a constant, we can calculate a 'base building' construction cost. This in turn allows us to identify where additional expenditure is required to facilitate the CO_2 reduction targets of four benchmarks, detailed below.

System 1 starts with the least number of LZC technologies possible for a typical services solution, and as the targets become more challenging, then more efficient conventional systems and/or LZC technologies are incorporated into the model(s) to augment or replace less efficient and/or non LZC

[1] These systems are to include decentralised energy supply systems based on energy from renewable sources, cogeneration, district or block heating or cooling, particularly where it is based entirely or partially on energy from renewable sources, and heat pumps.

technologies. System 2 on the other hand starts with LZC technologies, for example, primary fossil fuel heating is typically replaced with heat pumps. Simulations have been run against four benchmarks, these are:

1) The Building Emission Rate is equal to or lower than the Target Emission Rate (BER≤ TER). This is a requirement of Criterion 1 of Approved Document Part L2A of Building Regulations 2010 (Part L)
2) The BER must be 10% lower than the TER. This is the Extant Policy
3) The BER must be 15% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy A
4) The BER must be 20% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy B

1.2. Building Information Model (BIM)

To prepare this report we have used a building information model or BIM using IES engineering software - the Virtual Environment or VE. PDF drawings were provided to EVORA EDGE by GBC on a proposed development in Guildford for this study. These were converted into DWG files and scaled using AutoDesk AutoCad, and then in turn converted to DXF drawings so that they could be imported into the VE. We then imported additional models of commercial buildings from previous projects using gbXML and/or GEM files to create a 'virtual mixed use scheme'. This allowed us to model various types and numbers of buildings using a federated BIM which was shared between two principal energy modellers.

The BER and TER calculations and costs were all undertaken in the same model(s) and these are in turn available as IES Cabinet Files for future use. Nomenclature of itemised costs are based on the RICS New Rules of Measurement *Order of cost estimating and cost planning for capital building works*. A representation of the federated BIM is shown below.

1.3. Report Structure

This report has been arranged into the following sections. An executive summary, a more detailed tabulated section with basic technical information on our energy simulations, a summary of our costing methodology, and an extract from the BIMs showing our cost calculations and cost sources. Methodologies and sources of data have been clearly stated, however, it is important to note project limitations, which are expanded on in the section below.

1.4. Disclaimers

With any building, existing or proposed, there are almost an infinite number of design parameters for architects and engineers to consider including:

- Structure
- Orientation and Massing
- HVAC and Lighting Types
- Combination of HVAC and Fuel Types
- LZC Technologies

Whilst we have considered many scenarios, it is not possible to cover all potential design parameters. The aim of this research is to identify if it is possible to pass four benchmarks using the geometry and construction type of buildings which either already exist, or are proposed as part of a planning application; while assuming common design parameters and HVAC systems which are based upon a Notional Building or best (typical) market practice.

To do this we have looked at a number of building and system types adopting a hierarchical approach to favour the most efficient system(s). Where values or efficiencies are detailed in the Notional Building these are adopted. However where these values are not provided, or where they seem low when assessed against technologies readily available in the market, then these were replaced by values or efficiencies detailed in either Part L2A, or the Energy Technology List (ETL)[2], or other reputable or market sources.

[2] The ETL (or Energy Technology Product List, ETPL) is a government-managed list of energy-efficient plant and machinery, such as boilers, electric motors, and air conditioning and refrigeration systems that qualify for full tax relief.

Costs are indicative and for benchmarking purposes only. They exclude VAT and fees associated with design, professional services and project management. They do however include for preliminaries, profit and overheads for the services contractor. Build costs have typically been taken at the median of a range of costs detailed in SPONS 2017 unless indicated otherwise. Greater detail and information on our costing methodology has been provided in Section 4. of this report.

2. EXECUTIVE SUMMARY

Our findings over the following pages are summarised in the form of two schematics, one for each type of HVAC system including; a four pipe fan coil unit system and a variable refrigerant flow or volume system. Each schematic shows the effect of each iterative simulation on the BER in order to meet or better a benchmark, the financial cost to the developer for each metre square (m2) of building space to achieve this. Finally the schematic shows, expressed as a percentage increase, the cost of improving a building from Part L2A and the Extant Policy to a building that can comply with Proposed Policy B – the most stringent of the proposed policies.

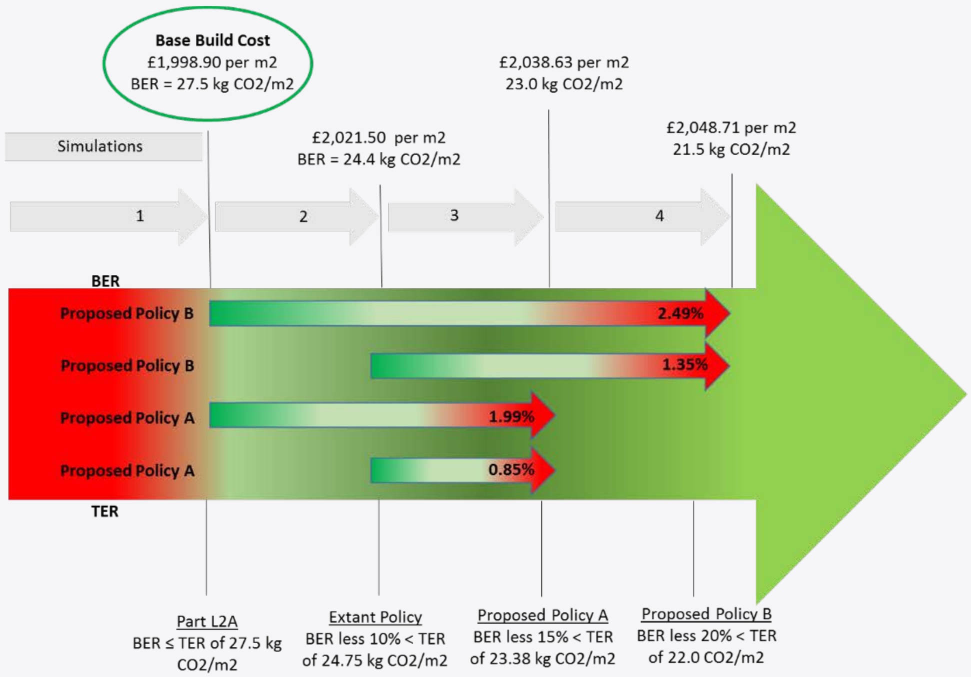
2.1 System 1: Results

System 1 is a four pipe fan coil unit (FCU) system with an ancillary low temperature hot water (LTHW) hydronic circuit to non–office space. A fan coil draws air across hot and/or cold water pipework and heat exchangers – preheated or precooled fresh air is typically ducted to the rear of each FCU. System 1 is capable of passing Part L2A and the Extant Policy but requires PV in both cases to do this. In order to pass Proposed Policies A and B a locally sited combined heat and power (CHP) plant is required – this is in addition to the PV. The results of the case studies are as follows:

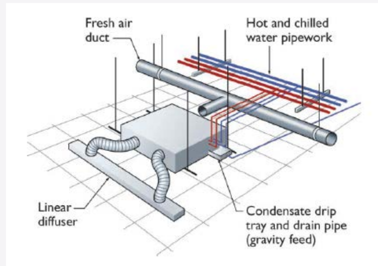
- The cost of Proposed Policy B is up to 2.49% more expensive than constructing a building that complies with Criterion 1 of Part L2A.
- The difference in cost between Extant Policy construction costs and Policy B construction costs is up to 1.35%.
- The cost of Proposed Policy A is up to 1.99% more expensive than constructing a building that complies with Criterion 1 of Part L2A.
- The difference in cost between Extant Policy construction costs and Policy A construction costs is up to 0.85%.

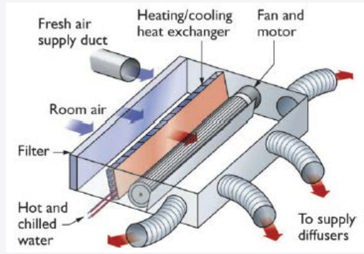
EVORA EDGE

System 1: Results schematic



Shown below is a typical 4 pipe fan coil unit system arrangement.





Source of pictures, the BSRIA Illustrated Guide to Mechanical Building Services

2.2 System 2: Results

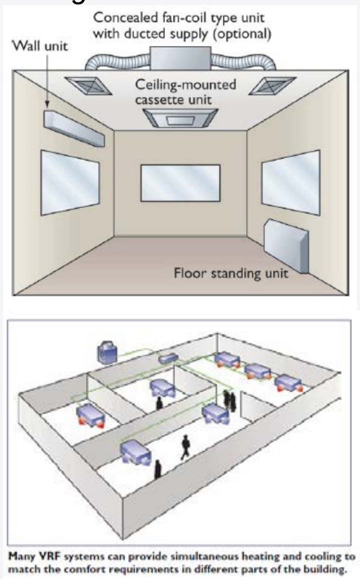
System 2 incorporates a variable refrigerant flow (VRF) or volume (VRV) system with mechanical ventilation and an ancillary low temperature hot water (LTHW) hydronic circuit to non–office space. Based on Annex 2 of GBC's Sustainable Design and Construction Supplementary Planning Document, air source heat pumps (ASHP) are classified as an LZC technology. VRF/V is an ASHP technology, typically with additional heat recovery, and under the right conditions can be extremely efficient. Unlike other sources of heating, energy is not converted to heat or cooling, but is instead consumed by plant moving heat from point A to point B. System 2 is capable of passing Part L2A without any additional LZC technology such as PV, but this is required in increasing capacity in order to pass the Extant Policy, Policy A and Policy B. The results of the case studies are as follows:

- The cost of Proposed Policy B is up to 1.66% more expensive than constructing a building that complies with Criterion 1 of Part L2A.
- The difference in cost between Extant Policy construction costs and Policy B construction costs is up to 1.20%.
- The cost of Proposed Policy A is up to 0.85% more expensive than constructing a building that complies with Criterion 1 of Part L2A.
- The difference in cost between Extant Policy construction costs and Policy A construction costs is up to 0.39%.

EVORA EDGE

System 2: Results schematic

Shown below is a typical VRV/F system arrangement.



Source of pictures, the BSRIA Illustrated Guide to Mechanical Building Services

2.3 A Comparison of System Performance

The table below compares the results of our simulations so that we can better understand cost-effectiveness alongside the impact on predicted CO_2 emissions. CO_2 emission are linked to energy consumption (kWh) and therefore, potentially, operational costs. System performance can be judged in two ways. The first, and in all probability, the most relevant to developers is establishing the most cost-effective way to reach Proposed Policy A or B. **This is highlighted in green**. In this case System 2, below, is the most cost-effective. Boxes that have been blacked out indicate that the previous simulation was capable of passing the target benchmark, and as a result it is not necessary to run additional simulations. For example, the simulation run to pass benchmark 1 for System 2 also passes benchmark 2, so this has been blacked out.

The second metric assesses the cost (£) of reducing CO_2 emissions. 0 = Zero operational carbon, the further away from zero the higher the cost (£) per Tonne (T) of CO_2 saved[3]. In this case, as an example, although System 2 is the most cost-effective system, for each £ invested per m^2 a greater amount of CO_2 savings are typically achieved for System 1 (with the exception of Simulation 1). As a result, it is likely that the operational running costs of System 1 will be the lowest of the two systems.

[3] Calculated as: BER * system cost / 1,000 (= Tonnes of CO_2)

Benchmark	System 1 BER kg CO_2/m^2	System 2 BER kg CO_2/m^2	System 1 Cost per m^2	System 2 Cost per m^2
The BER ≤ TER. This is a requirement of Criterion 1 of Part L2A	27.5	27.3	£1,998.90 / m^2 £54.97 / TCO_2	£1,961.75 / m^2 £53.56/ TCO_2
The BER must be 10% lower than the TER. This is the Extant Policy	24.4	25.3	£2,021.50 / m^2 £49.32 / TCO_2	£1,970.64 / m^2 £49.86 / TCO_2
The BER must be 15% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy A	23.0	23.9	£2,038.63 / m^2 £46.89 / TCO_2	£1,978.34 / m^2 £47.28 / TCO_2
The BER must be 20% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy B	21.5	22.4	£2,048.71 / m^2 £44.05 / TCO_2	£1,994.35 / m^2 £44.67 / TCO_2

3. SIMULATION RESULTS

The following two tables provide greater detail and granularity to the modelled buildings. The columns show the simulation number (1 to 4), the building type and target benchmark, the BER and TER, indicative costs and salient technical details.

3.1 System 1: 4 Pipe Fan Coil Unit System with Mechanical Ventilation

Simulation	Building and target benchmark	BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
1	**Building type** Large Office Building. **Benchmark** The BER ≤ TER. This is a requirement of Criterion 1 of Part L2A. **Summary - pass** This modelled building complies with Criterion 1 of Part L2A of Building Regulations, and is the base case building.	27.5 BER = TER	27.5	£21,835,960.00 or £1,998.90 per functional unit (m^2).	**Building fabric** Air permeability at 50 Pa ($m^3/(h.m^2)$) = 5 Fabric U values, as per the Notional Building Glazing g values, as per the Notional Building **HVAC** Heating A 4 pipe fan coil unit system to all office areas, and a low temperature hot water (LTHW) system to all other areas requiring heating. The heat source is a gas-fired boiler with a gross efficiency of 91% as per the Notional Building.

Simulation	Building and target benchmark	BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
	However to pass a 23 kWp PV renewable energy system is required from the outset.				All pumps are variable speed with multiple pressure sensors. Ventilation Full mechanical ventilation with heat recovery at 70% efficiency, and a specific fan power (SFP) of 1.8 w/l/s as per the Notional Building. The air handling unit (AHU) and ductwork leakage have been taken at CEN standards Class D and L1. Air conditioning Air-cooled chillers with a cooling SSEER[4] of 3.6 as per the Notional Building. NB: technical note - for offices (only) ESEER can be adopted as the SEER. This directly affects the SSEER calculation.

[4] SSEER and ESEET is a measure of air conditioning efficiency over a cooling season. In this example for every unit of energy input 3.6 units of cooling is transferred as an output.

Simulation	Building and target benchmark	BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
					Domestic Hot Water Unvented electric storage heaters located on each floor close to the source of demand with a combined capacity of 1000 litres. Heat loss as per Table 27 of the Non-Domestic Building services Compliance Guide 2013. **Lighting** 60 lumens per circuit-watt, 100 lux – circulation space 60 lumens per circuit-watt, 500 lux all other spaces 60 lumens is the level of efficiency in the Notional Building. **Lighting controls** Photoelectric – typically yes Motion sensors – typically yes **Renewable energy systems** A 23 kWp mono crystalline silicon PV system due south east with little shade. This will require 276 m^2 of flat roof space (to account for spacing and A frames etc.) on a building with 1265 m^2 of flat roof space.

Simulation	Building and target benchmark	BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
					Design challenges/considerations None to mention as this is a fairly typical (building) services solution to large office buildings. NB: For buildings with a large hot water demand then a centralized hot water calorifier system may need to be installed.
2	**Building type** Large Office Building. **Benchmark** The BER must be 10% lower than the TER. This is the extant borough policy. **Summary** - pass The BER of this modelled building is >10% less than the TER as a result of the PV renewable energy system which has facilitated an 11.27% reduction against the TER.	24.4 The BER is 11.27% less than the TER (the TER detailed in Simulation 1)	24.75 (this is the target under the Extant Policy. It is the TER less 10%)	£22,082,848.00 or £2,021.50 per functional unit (m2). This represents an increase of £246,888.00 or 1.13% over the base build cost.	Technical details as per Simulation 1 but with an increased PV system of 100 kWp. This will require 1,200 m^2 of flat roof space (to account for spacing and A frames etc.) on a building with 1265 m^2 of flat roof space. **Design challenges/considerations** A large PV system of this size would create design challenges in terms of location of external plant/access etc.

Simulation	Building and target benchmark	BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
3	**Building type** Large Office Building. **Benchmark** The BER must be 15% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy A. **Summary - pass** The BER of this modelled building is >15% less than the TER as a result of a PV renewable energy system AND CHP, which together has facilitated a 16.36% reduction against the TER.	23.0 The BER is 16.36% less than the TER (the TER detailed in Simulation 1)	23.38 (this is the target under Proposed Policy A. It is the TER less 15%)	£22,270,048.00 or £2,038.63 per functional unit (m2). This represents an increase of £434,088.00 or 1.98% over the base build cost.	Technical details as per Simulation 2 but with a combined heat and power (CHP) unit with the following specifications: Fuel type: Gas Thermal seasonal efficiency: 0.5 Fraction of space heat supplied: 0.45 Fraction of DHW supplied: 0.0 Heat to power ratio: 1:50 CHPQA Index: 105.00 **Design challenges/considerations** Although CHP reduces the BER, from an operational perspective for the technology to be economically viable an all year round heat load is required which is not present in the modelled building.
4	**Building type** Large Office Building. **Benchmark** The BER must be 20% lower than the TER. This is a proposed borough	21.5 The BER is 21.82% less than the TER	22 (this is the target under Proposed Policy A. It	£22,380,162.00 or £2,048.71 per functional unit (m2).	Technical details as per Simulation 3. The specification of the chiller has been increased to include 'free-cooling' with an improved ESEER of 6.23 and a SSEER of >4.9. This is based on technologies that are available in the market place such as http://www.airedale.com/web/Products/Chillers/TurboChill-

Simulation	Building and target benchmark	BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
	policy which we refer to as Proposed Policy B. **Summary – possible fail** The BER of this modelled building is >20% less than the TER. Of this 6.9 kg CO_2/m^2 is from a PV renewable energy system, a gas fired CHP engine, and free cooling (whereby the condenser is bypassed using ambient temperatures as/when these are low enough). This amounts to a reduction to the BER (without PV, CHP or free cooling) of 25%. However, only 19% of this reduction is from LZC technologies (if you exclude the free cooling) resulting (as per simulation 3) in a 16.36% reduction against the TER. In summary it is difficult for the BER to be >20% less than the TER by only using LZC unless free cooling, or other such technologies, are classed	(the TER detailed in Simulation 1)	is the TER less 20%)	This represents an increase of £544,202 or 2.49% over the base build cost.	R1234ze-Free-Cooling-Chiller.htm (other manufacturers and models exist). NB: technical note - for offices (only) ESEER can be adopted as the SEER. This directly affects the SSEER calculation.

Simulation	Building and target benchmark	BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
	as an LZC by Guildford Borough Council. This would require a degree of design flexibility on the part of GBC.				

3.2 System 2: VRV/F System with Mechanical Ventilation

Simulation	Building and target benchmark	BER kg CO2/m2	TER kg CO2/m2	Indicative costs of construction	Technical detail
1	**Building type** Large Office Building. **Benchmark** The BER ≤ TER. This is a requirement of Criterion 1 of Part L2A. **Summary - pass** This modelled building complies with Criterion 1 of Part L2A of Building Regulations, and is the base case building.	27.3 BER is 3.19% less than the TER	28.2	£21,430,124.00 or £1,961.75 per functional unit (m^2).	**Building fabric** Air permeability 5 at 50 Pa (m3/(h.m2) = 5 U values, as per the Notional Building g values, as per the Notional Building **HVAC** Heating A VRV/F air-source-heat-pump (ASHP) system to all office areas, and a low temperature hot water (LTHW) system to all other areas requiring heating.

Simulation	Building and target benchmark	BER kg CO2/m2	TER kg CO2/m2	Indicative costs of construction	Technical detail
	The principal heating system modelled is an efficient air source heat pump system known as a variable refrigerant volume (VRV) or flow (VRF), and this is classified as an LZC technology by GBC.				The CoP of the ASHP is 3.9[5] which is a requirement of the Energy Technology List and is higher than the Notional Building. The heat source is a gas-fired boiler with a gross efficiency of 91% as per the Notional Building. All pumps are variable speed with multiple pressure sensors. Ventilation Full mechanical ventilation with heat recovery at 70% efficiency, and a specific fan power (SFP) of 1.2 w/l/s as per the Notional Building (a technical anomaly of modelling against the NCM is that the SFP must be lower for system 2 than system 1 and this has been reflected in costs). The air handling unit (AHU) and ductwork leakage have been taken at CEN standards Class D and L1.

[5] Coefficient of Performance (CoP). For every unit of energy input 3.9 units of heat is delivered as an output under test conditions

Simulation	Building and target benchmark	BER kg CO2/m2	TER kg CO2/m2	Indicative costs of construction	Technical detail
					Air conditioning The SSEER of the VRV/F system is 3.6 (requiring an ESEER of 4.9) as per the Notional Building. **Domestic Hot Water** Unvented electric storage heaters located on each floor close to the source of demand with a combined capacity of 1000 litres. Heat loss as per Table 27 of the Non-Domestic Building services Compliance Guide 2013. **Lighting** 60 lumens per circuit-watt, 100 lux – circulation space 60 lumens per circuit-watt, 500 lux all other spaces **Lighting controls** Photoelectric – typically yes Motion sensors – typically no (to the common areas and office area only). **Design challenges/considerations**

Simulation	Building and target benchmark	BER kg CO2/m2	TER kg CO2/m2	Indicative costs of construction	Technical detail
					None to mention as this is a fairly typical (building) services solution to large office buildings. NB: For buildings with a large hot water demand then a centralized hot water calorifier system may need to be installed.
2	**Building type** Large Office Building. **Benchmark** The BER must be 10% lower than the TER. This is the extant borough policy. **Summary - pass** The BER of this modelled building is >10% less than the TER. Of this approx. 7.4kg[6] CO_2/m^2 is from the ASHP and the PV renewable energy	25.3 BER is 10.28% less than the TER (the TER detailed in Simulation 1)	25.38 (this is the target under the Extant Policy. It is the TER less 10%)	£21,527,324.00 or £1,970.64 per functional unit (m^2). This represents an increase of £97,200.00 or 0.45% over the base build cost.	Technical details as per Simulation 1 but with a PV system of 50 kWp. This will require 600 m^2 of flat roof space (to account for spacing and A frames etc.) on a building with 1265 m^2 of flat roof space.

[6] Of the 7.4 kg CO_2/m^2, 1.96 CO_2/m^2 is a result of a saving/reduction in emissions through PV. The remainder is the heat 'generated' by the ASHP which replaces heat that would otherwise be generated by non-LZC technologies. This assumes 70% of heat energy consumed is by the ASAP system. Electrical emissions taken at 0.519 kg CO_2 per kWh (SAP 2012).

Simulation	Building and target benchmark	BER kg CO2/m2	TER kg CO2/m2	Indicative costs of construction	Technical detail
	system facilitating the 10.28% reduction against the TER.				
3	**Building type** Large Office Building. **Benchmark** The BER must be 15% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy A. **Summary - pass** The BER of this modelled building is >15% less than the TER. Of this approx. 7.83kg[7] CO_2/m^2 is from the ASHP and the PV renewable energy system facilitating a 15.24% reduction against the TER. See footnote 6 for a more detailed explanation on how these calculations are arrived at.	23.9 BER is 15.24% less than the TER (the TER detailed in Simulation 1)	23.97 (this is the target under the Extant Policy. It is the TER less 15%)	£21,611,364.00 or £1,978.34 per functional unit (m2). This represents an increase of £181,240.00 or 0.85% over the base build cost.	Technical details as per Simulation 1 but with a PV system of 60 kWp and a more efficient VRV/F system with a SEER of 6.00 and an SSEER of 4.48. A 60kWp PV system will require 720 m^2 of flat roof space (to account for spacing and A frames etc.) on a building with 1265 m^2 of flat roof space. NB: VRF/V systems with these levels of efficiency are readily available on the market. An example is the Daikin RYYQ-T (36 to 42 HP) range (other manufacturers and models exist).

[7] Assumes 70% of energy consumed is from the ASAP system. Electrical emissions taken at 0.519 kg CO2 per kWh (SAP 2012)

Simulation	Building and target benchmark	BER kg CO2/m2	TER kg CO2/m2	Indicative costs of construction	Technical detail
4	**Building type** Large Office Building. **Benchmark** The BER must be 20% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy B. **Summary - pass** The BER of this modelled building is >20% less than the TER. Of this approx. 9.32kg[8] CO_2/m^2 is from the ASHP and the PV renewable energy system facilitating a 20.57% reduction against the TER. See footnote 6 for a more detailed explanation on how these calculations are arrived at.	22.4 BER is 20.57% less than the TER (the TER detailed in Simulation 1)	22.56 (this is the target under the Extant Policy. It is the TER less 20%)	£21,786,324.00 or £1,994.35 per functional unit (m2). This represents an increase of £356,200.00 or 1.66% over the base build cost.	This will require 1,200 m^2 of flat roof space (to account for spacing and A frames etc.) on a building with 1265 m^2 of flat roof space. **Design challenges/considerations** A large PV system of this size would create design challenges in terms of location of external plant/access etc.

[8] Assumes 70% of energy consumed is from the ASAP system. Electrical emissions taken at 0.519 kg CO2 per kWh (SAP 2012)

4. COSTS

The costs detailed over the following pages have been taken from the BIMs which are available as cabinet files (CAB files). The headings include an ID, a code which defines the basis of the cost multiplier, a rate (£), quantity, weight, base cost, cost £, and cost £ /. Explanations are provided below:

1.1 ID

The ID is based on the nomenclature of the RICS New Rules of Measurement.

1.2 Code

The code is assigned through the VE and informs the quantity. Code 11, as an example, is the code for multiplying the rate by the quantity which is based on the Gross Internal Floor Area (GIFA), while Code 1 measures the quantity by item. For example, 1 or 2 No. boilers etc.

1.3 Rate

This is the rate (£) to be multiplied by the quantity.

1.4 Quantity

This is the basis of the cost multiplier.

1.5 Weight

This applies a weighted value to the quantity, a weight of 1 = 100% as a multiplier against the quantity. In the costs below a rate of £2,625.50 per m^2 has been adopted as the build cost, however this sum includes building services. Using BSRIA Rules of thumb as a guide, we have applied a discount rate to allow us to extract typical building services costs from the inclusive development cost. This is so that we can analyse the impact of different building services (on costs). For example, an adjusted weighting of 0.18 results in a weighting of 0.82 (1 – 0.18 = 0.82). The purpose of the exercise is to provide a consistent 'base build cost' across the simulations with the final project inclusive cost (i.e. with building services) reassessed against the range of costs provided in SPONS 2017[9]. The following weighting rules have been adopted throughout the project:

Property type	HVAC system type	Unadjusted BSRIA weighting	Less allowance for lifts[10] etc.	Adjusted weighting
Commercial (Offices)	Natural ventilation and no air conditioning	0.30	0.05	0.25
Commercial (Offices)	Mechanical ventilation and air conditioning	0.34	0.05	0.29
Commercial (Retail)	Mechanical ventilation and air conditioning	0.21	N/A	0.21
Commercial (Care Homes etc.)	Natural ventilation and no air conditioning	0.23	0.05	0.18
Commercial (Care Homes etc.)	Mechanical ventilation and air conditioning	0.33	0.05	0.28
Residential	Natural ventilation and no air conditioning	0.23	0.025	0.205

[9] In other words we would expect the project Cost per m2 to be within the range provided by SPONS 2017 after an adjustment for location.
[10] Items included in the BSRIA weighting have been added in our cost modelling as separate line items using the RICS NRM and therefore an allowance needs to be made (discounted) to avoid double counting.

NB: Where adjustments to the weighting are made under RICS NRM item 5.6, these simply apportion the area conditioned by the system subject to the adjustment. For example if a fan coil unit services approximately 70% of a building, then a weighting of 0.7 is applied.

1.6 Base Cost

The base cost is an unadjusted cost (rate x quantity).

1.7 Cost

This is the adjusted cost. It is the cost multiplied by a location adjustment factor, a quality factor, and a complexity factor. In SPONS 2017 the location adjustment factor for the south east is 0.96, while a quality and complexity factor of unity (1) has been applied in the BIM representing a medium quality, medium complexity development for the type of building modelled.

1.8 Cost £ /

This is the cost per functional unit. In this case the functional unit is taken as m^2.

EVORA EDGE

5. SYSTEM 1, SIMULATION 1

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Large Office Building**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost)	11	2,262.50	10,924	0.71	17,548,040.00	16,846,118.00	1,542.12
5	Services (BES)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	8.83	10,924	1.00	96,458.93	92,600.57	8.48
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	20.95	10,924	1.00	228,857.80	219,703.50	20.11
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	23.00	10,924	1.00	251,252.00	241,201.92	22.08
5.5	Heat source (HS) Boiler ((GIFA x 70w x £50.00 per kW (SPONS M&E 2017))	1	38,234.00	1	1.00	38,234.00	36,704.64	3.36
5.6	Space heating and air conditioning (SHAC) 4 pipe FCU (SPONS M&E 2017 - median cost)	11	140.00	10,924	0.70	1,070,552.00	1,027,729.81	94.08
5.6	Space heating LTHW for non FCU space (SPONS M&E 2017 - median cost)	11	59.00	10,924	0.30	193,354.81	185,620.59	16.99
5.7	Ventilation systems (VS) (SPONS M&E 2017 - median cost)	11	38.00	10,924	1.00	415,112.00	398,507.47	36.48
5.8.1	Electrical mains and sub-mains distribution (SPONS M&E 2017 - median cost)	11	41.00	10,924	1.00	447,884.00	429,968.63	39.36
5.8.2	Power installations (SPONS M&E 2017 - median cost)	11	14.95	10,924	1.00	163,313.80	156,781.23	14.35
5.8.3	Lighting installations (SPONS M&E 2017 - median cost)	11	72.00	10,924	1.00	786,528.00	755,066.88	69.12
5.8.5	Local electricity generation systems (SPONS M&E 2017 - median cost)	11	2,025.00	23	1.00	46,575.00	44,712.00	4.09
5.8.5	Stand by generator (SPONS M&E 2017 - median cost)	11	21.00	10,924	1.00	229,404.00	220,227.81	20.16
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	1.15	10,924	1.00	12,562.60	12,060.10	1.10
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	4	1.00	264,000.00	253,440.00	23.20
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	34.90	10,924	1.00	381,247.59	365,997.72	33.50
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	52.40	10,924	1.00	572,417.63	549,520.94	50.30
							21,835,960.00	**1,998.90**
	CAPITAL COST						**21,835,960.00**	**1,998.90**

EVORA EDGE

6. SYSTEM 1, SIMULATION 2

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Large Office Building**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost)	11	2,262.50	10,924	0.71	17,548,040.00	16,846,118.00	1,542.12
5	Services (BES)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	8.83	10,924	1.00	96,458.93	92,600.57	8.48
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	20.95	10,924	1.00	228,857.80	219,703.50	20.11
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	23.00	10,924	1.00	251,252.00	241,201.92	22.08
5.5	Heat source (HS) - boilers ((GIFA x 70w x £50.00 per kW (SPONS M&E 2017))	1	38,234.00	1	1.00	38,234.00	36,704.64	3.36
5.5	Heat source (HS) gas fired CHP ((GIFA x 35w = (SPONS M&E 2017) 359 kW heat output CHP))	1	195,000.00	0	1.00	0.00	0.00	0.00
5.6	Space heating and air conditioning (SHAC) 4 pipe FCU (SPONS M&E 2017 - median cost)	11	140.00	10,924	0.70	1,070,552.00	1,027,729.81	94.08
5.6	Space heating LTHW for non FCU space (SPONS M&E 2017 - median cost)	11	59.00	10,924	0.30	193,354.81	185,620.59	16.99
5.7	Ventilation systems (VS) (SPONS M&E 2017 - median cost)	11	38.00	10,924	1.00	415,112.00	398,507.47	36.48
5.8.1	Electrical mains and sub-mains distribution (SPONS M&E 2017 - median cost)	11	41.00	10,924	1.00	447,884.00	429,968.63	39.36
5.8.2	Power installations (SPONS M&E 2017 - median cost)	11	14.95	10,924	1.00	163,313.80	156,781.23	14.35
5.8.3	Lighting installations (SPONS M&E 2017 - median cost)	11	72.00	10,924	1.00	786,528.00	755,066.88	69.12
5.8.5	PV panels (SPONS M&E 2017 - median cost, increased by 50% to allow for additional frame work)	11	3,037.50	100	1.00	303,750.03	291,600.00	26.69
5.8.5	Stand by generator (SPONS M&E 2017 - median cost)	11	21.00	10,924	1.00	229,404.00	220,227.81	20.16
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	1.15	10,924	1.00	12,562.60	12,060.10	1.10
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	11	66,000.00	4	1.00	264,000.00	253,440.00	23.20
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	34.90	10,924	1.00	381,247.59	365,997.72	33.50
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	52.40	10,924	1.00	572,417.63	549,520.94	50.30
							22,082,848.00	**2,021.50**
	CAPITAL COST						**22,082,848.00**	**2,021.50**

EVORA EDGE

7. SYSTEM 1, SIMULATION 3

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Large Office Building**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost)	11	2,262.50	10,924	0.71	17,548,040.00	16,846,118.00	1,542.12
5	Services (BES)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	8.83	10,924	1.00	96,458.93	92,600.57	8.48
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	20.95	10,924	1.00	228,857.80	219,703.50	20.11
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	23.00	10,924	1.00	251,252.00	241,201.92	22.08
5.5	Heat source (HS) - boilers ((GIFA x 70w x £50.00 per kW (SPONS M&E 2017))	1	38,234.00	1	1.00	38,234.00	36,704.64	3.36
5.5	Heat source (HS) gas fired CHP ((GIFA x 35w = (SPONS M&E 2017) 359 kW heat output CHP))	1	195,000.00	1	1.00	195,000.00	187,200.00	17.14
5.6	Space heating and air conditioning (SHAC) 4 pipe FCU (SPONS M&E 2017 - median cost)	11	140.00	10,924	0.70	1,070,552.00	1,027,729.81	94.08
5.6	Space heating LTHW for non FCU space (SPONS M&E 2017 - median cost)	11	59.00	10,924	0.30	193,354.81	185,620.59	16.99
5.7	Ventilation systems (VS) (SPONS M&E 2017 - median cost)	11	38.00	10,924	1.00	415,112.00	398,507.47	36.48
5.8.1	Electrical mains and sub-mains distribution (SPONS M&E 2017 - median cost)	11	41.00	10,924	1.00	447,884.00	429,968.63	39.36
5.8.2	Power installations (SPONS M&E 2017 - median cost)	11	14.95	10,924	1.00	163,313.80	156,781.23	14.35
5.8.3	Lighting installations (SPONS M&E 2017 - median cost)	11	72.00	10,924	1.00	786,528.00	755,066.88	69.12
5.8.5	Local electricity generation systems	11	3,037.50	100	1.00	303,750.03	291,600.00	26.69
5.8.5	Stand by generator (SPONS M&E 2017 - median cost)	11	21.00	10,924	1.00	229,404.00	220,227.81	20.16
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	1.15	10,924	1.00	12,562.60	12,060.10	1.10
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	4	1.00	264,000.00	253,440.00	23.20
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	34.90	10,924	1.00	381,247.59	365,997.72	33.50
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	52.40	10,924	1.00	572,417.63	549,520.94	50.30
							22,270,048.00	**2,038.63**
	CAPITAL COST						**22,270,048.00**	**2,038.63**

8. SYSTEM 1, SIMULATION 4

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Care Home**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost)	11	2,262.50	10,924	0.71	17,548,040.00	16,846,118.00	1,542.12
5	Services (BES)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	8.83	10,924	1.00	96,458.93	92,600.57	8.48
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	20.95	10,924	1.00	228,857.80	219,703.50	20.11
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	23.00	10,924	1.00	251,252.00	241,201.92	22.08
5.5	Heat source (HS) - boilers ((GIFA x 70w x £50.00 per kW (SPONS M&E 2017))	1	38,234.00	1	1.00	38,234.00	36,704.64	3.36
5.5	Heat source (HS) gas fired CHP ((GIFA x 35w = (SPONS M&E 2017) 359 kW heat output CHP))	1	195,000.00	1	1.00	195,000.00	187,200.00	17.14
5.6	Space heating and air conditioning (SHAC) 4 pipe FCU (SPONS M&E 2017 - upper end cost) to accou...	11	155.00	10,924	0.70	1,185,254.00	1,137,843.88	104.16
5.6	Space heating LTHW for non FCU space (SPONS M&E 2017 - median cost)	11	59.00	10,924	0.30	193,354.81	185,620.59	16.99
5.7	Ventilation systems (VS) (SPONS M&E 2017 - median cost)	11	38.00	10,924	1.00	415,112.00	398,507.47	36.48
5.8.1	Electrical mains and sub-mains distribution (SPONS M&E 2017 - median cost)	11	41.00	10,924	1.00	447,884.00	429,968.63	39.36
5.8.2	Power installations (SPONS M&E 2017 - median cost)	11	14.95	10,924	1.00	163,313.80	156,781.23	14.35
5.8.3	Lighting installations (SPONS M&E 2017 - median cost)	11	72.00	10,924	1.00	786,528.00	755,066.88	69.12
5.8.5	PV panels (SPONS M&E 2017 - median cost, increased by 50% to allow for additional frame work)	11	3,037.50	100	1.00	303,750.03	291,600.00	26.69
5.8.5	Stand by generator (SPONS M&E 2017 - median cost)	11	21.00	10,924	1.00	229,404.00	220,227.81	20.16
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	1.15	10,924	1.00	12,562.60	12,060.10	1.10
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	4	1.00	264,000.00	253,440.00	23.20
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	34.90	10,924	1.00	381,247.59	365,997.72	33.50
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	52.40	10,924	1.00	572,417.63	549,520.94	50.30
							22,380,162.00	**2,048.71**
	CAPITAL COST						**22,380,162.00**	**2,048.71**

EVORA EDGE

9. SYSTEM 2, SIMULATION 1

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Large Office Building**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost)	11	2,262.50	10,924	0.71	17,548,040.00	16,846,118.00	1,542.12
5	Services (BES)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	8.83	10,924	1.00	96,458.93	92,600.57	8.48
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	20.95	10,924	1.00	228,857.80	219,703.50	20.11
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	23.00	10,924	1.00	251,252.00	241,201.92	22.08
5.5	Heat source (HS) - boilers ((GIFA x 0.3 x 70w x £50.00 per kW (SPONS M&E 2017))	1	16,000.00	1	1.00	16,000.00	15,360.00	1.41
5.6	Space heating and air conditioning (SHAC) VRF/V system (SPONS M&E 2017 - upper end to aim for ...	11	88.00	10,924	0.70	672,918.38	646,001.63	59.14
5.6	Space heating LTHW for non VRF/V space (SPONS M&E 2017 - median cost)	11	59.00	10,924	0.30	193,354.81	185,620.59	16.99
5.7	Ventilation systems (VS) (SPONS M&E 2017 - upper end cost to acheive improved SFP)	11	42.00	10,924	1.00	458,808.00	440,455.63	40.32
5.8.1	Electrical mains and sub-mains distribution (SPONS M&E 2017 - median cost)	11	41.00	10,924	1.00	447,884.00	429,968.63	39.36
5.8.2	Power installations (SPONS M&E 2017 - median cost)	11	14.95	10,924	1.00	163,313.80	156,781.23	14.35
5.8.3	Lighting installations (SPONS M&E 2017 - median cost)	11	72.00	10,924	1.00	786,528.00	755,066.88	69.12
5.8.5	Stand by generator (SPONS M&E 2017 - median cost)	11	21.00	10,924	1.00	229,404.00	220,227.81	20.16
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	1.15	10,924	1.00	12,562.60	12,060.10	1.10
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	11	66,000.00	4	1.00	264,000.00	253,440.00	23.20
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	34.90	10,924	1.00	381,247.59	365,997.72	33.50
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	52.40	10,924	1.00	572,417.63	549,520.94	50.30
							21,430,124.00	**1,961.75**
	CAPITAL COST						**21,430,124.00**	**1,961.75**

EVORA EDGE

10. SYSTEM 2, SIMULATION 2

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Large Office Building**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost)	11	2,262.50	10,924	0.71	17,548,040.00	16,846,118.00	1,542.12
5	Services (BES)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	8.83	10,924	1.00	96,458.93	92,600.57	8.48
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	20.95	10,924	1.00	228,857.80	219,703.50	20.11
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	23.00	10,924	1.00	251,252.00	241,201.92	22.08
5.5	Heat source (HS) - boilers ((GIFA x 0.3 x 70w x £50.00 per kW (SPONS M&E 2017))	1	16,000.00	1	1.00	16,000.00	15,360.00	1.41
5.6	Space heating and air conditioning (SHAC) VRF/V system (SPONS M&E 2017 - upper cost to aim for ...	11	88.00	10,924	0.70	672,918.38	646,001.63	59.14
5.6	Space heating LTHW for non VRF/V space (SPONS M&E 2017 - median cost)	11	59.00	10,924	0.30	193,354.81	185,620.59	16.99
5.7	Ventilation systems (VS) (SPONS M&E 2017 - upper end cost)	11	42.00	10,924	1.00	458,808.00	440,455.63	40.32
5.8.1	Electrical mains and sub-mains distribution (SPONS M&E 2017 - median cost)	11	41.00	10,924	1.00	447,884.00	429,968.63	39.36
5.8.2	Power installations (SPONS M&E 2017 - median cost)	11	14.95	10,924	1.00	163,313.80	156,781.23	14.35
5.8.3	Lighting installations (SPONS M&E 2017 - median cost)	11	72.00	10,924	1.00	786,528.00	755,066.88	69.12
5.8.5	PV panels (SPONS M&E 2017 - median cost)	11	2,025.00	50	1.00	101,250.01	97,200.01	8.90
5.8.5	Stand by generator (SPONS M&E 2017 - median cost)	11	21.00	10,924	1.00	229,404.00	220,227.81	20.16
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	1.15	10,924	1.00	12,562.60	12,060.10	1.10
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	4	1.00	264,000.00	253,440.00	23.20
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	34.90	10,924	1.00	381,247.59	365,997.72	33.50
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	52.40	10,924	1.00	572,417.63	549,520.94	50.30
							21,527,324.00	**1,970.64**
	CAPITAL COST						**21,527,324.00**	**1,970.64**

EVORA EDGE

11. SYSTEM 2, SIMULATION 3

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Large Office Building**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost)	11	2,262.50	10,924	0.71	17,548,040.00	16,846,118.00	1,542.12
5	Services (BES)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	8.83	10,924	1.00	96,458.93	92,600.57	8.48
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	20.95	10,924	1.00	228,857.80	219,703.50	20.11
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	23.00	10,924	1.00	251,252.00	241,201.92	22.08
5.5	Heat source (HS) - boilers ((GIFA x 0.3 x 70w x £50.00 per kW (SPONS M&E 2017))	1	16,000.00	1	1.00	16,000.00	15,360.00	1.41
5.6	Space heating and air conditioning (SHAC) VRF/V system (SPONS M&E 2017 - upper end cost + 10...	11	96.80	10,924	0.70	740,210.25	710,601.75	65.05
5.6	Space heating LTHW for non VRF/V space (SPONS M&E 2017 - median cost)	11	59.00	10,924	0.30	193,354.81	185,620.59	16.99
5.7	Ventilation systems (VS) (SPONS M&E 2017 - upper end cost for increased SFP)	11	42.00	10,924	1.00	458,808.00	440,455.63	40.32
5.8.1	Electrical mains and sub-mains distribution (SPONS M&E 2017 - median cost)	11	41.00	10,924	1.00	447,884.00	429,968.63	39.36
5.8.2	Power installations (SPONS M&E 2017 - median cost)	11	14.95	10,924	1.00	163,313.80	156,781.23	14.35
5.8.3	Lighting installations (SPONS M&E 2017 - median cost)	11	72.00	10,924	1.00	786,528.00	755,066.88	69.12
5.8.5	PV panels (SPONS M&E 2017 - median cost)	11	2,025.00	60	1.00	121,500.01	116,640.01	10.68
5.8.5	Stand by generator (SPONS M&E 2017 - median cost)	11	21.00	10,924	1.00	229,404.00	220,227.81	20.16
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	1.15	10,924	1.00	12,562.60	12,060.10	1.10
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	4	1.00	264,000.00	253,440.00	23.20
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	34.90	10,924	1.00	381,247.59	365,997.72	33.50
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	52.40	10,924	1.00	572,417.63	549,520.94	50.30
							21,611,364.00	**1,978.34**
							21,611,364.00	**1,978.34**

EVORA EDGE

12. SYSTEM 2, SIMULATION 4

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Large Office Building**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost)	11	2,262.50	10,924	0.71	17,548,040.00	16,846,118.00	1,542.12
5	Services (BES)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	8.83	10,924	1.00	96,458.93	92,600.57	8.48
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	20.95	10,924	1.00	228,857.80	219,703.50	20.11
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	23.00	10,924	1.00	251,252.00	241,201.92	22.08
5.5	Heat source (HS) - boilers ((GIFA x 0.3 x 70w x £50.00 per kW (SPONS M&E 2017))	1	16,000.00	1	1.00	16,000.00	15,360.00	1.41
5.6	Space heating and air conditioning (SHAC) VRF/V system (SPONS M&E 2017 - upper end cost + 10...	11	96.80	10,924	0.70	740,210.25	710,601.75	65.05
5.6	Space heating LTHW for non VRF/V space (SPONS M&E 2017 - median cost)	11	59.00	10,924	0.30	193,354.81	185,620.59	16.99
5.7	Ventilation systems (VS) (SPONS M&E 2017 - upper end cost to account for reduced SFP)	11	42.00	10,924	1.00	458,808.00	440,455.63	40.32
5.8.1	Electrical mains and sub-mains distribution (SPONS M&E 2017 - median cost)	11	41.00	10,924	1.00	447,884.00	429,968.63	39.36
5.8.2	Power installations (SPONS M&E 2017 - median cost)	11	14.95	10,924	1.00	163,313.80	156,781.23	14.35
5.8.3	Lighting installations (SPONS M&E 2017 - median cost)	11	72.00	10,924	1.00	786,528.00	755,066.88	69.12
5.8.5	PV panels (SPONS M&E 2017 - median cost, increased by 50% to allow for additional frame work)	11	3,037.50	100	1.00	303,750.03	291,600.00	26.69
5.8.5	Stand by generator (SPONS M&E 2017 - median cost)	11	21.00	10,924	1.00	229,404.00	220,227.81	20.16
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	1.15	10,924	1.00	12,562.60	12,060.10	1.10
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	4	1.00	264,000.00	253,440.00	23.20
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	34.90	10,924	1.00	381,247.59	365,997.72	33.50
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	52.40	10,924	1.00	572,417.63	549,520.94	50.30
							21,786,324.00	**1,994.35**
							21,786,324.00	**1,994.35**

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